Schools, Computers, and Learning Project

YES, BUT ARE THEY LEARNING ANYTHING?

Interim Report #3 From the Kingston Regional Pilot Test Centre

JULIA BLACKSTOCK
LARRY MILLER

This research project was funded under contract by the Ministry of Education, Ontario.
It reflects the views of the authors and not necessarily those of the Ministry.

Chris Ward, Minister
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Abstract

The Schools, Computers, and Learning Project (SCL) was designed to investigate the mutual adaptation of new information technology in an elementary school setting. The SCL Project involves five principal researchers, each focusing on a different area of interest and expertise. The component of the longitudinal investigation described in this report included four original research goals, however, as the study ensued, these goals were modified and expanded to include:

1. The study of a group of Grade 1 children, and their use of computers, as they progressed through three years of schooling.
2. The study of one teacher using computers over a three-year period.
3. The study of the computer's role in fostering literacy.
4. A study of the transfer of learning.
5. The study of one particular software package, THE PUZZLER, and a demonstration of its exemplary use in the classroom.

During the initial year, the first four goals served as the prime focus of the investigation. The fifth goal was designated for study in the second year of the project.

The findings of this report were based on the intensive study of one Grade 1 classroom, both children and the teacher. The researchers used qualitative methods for data gathering including analyses of field notes, interviews with the classroom teacher at the beginning of the SCL Project and end of the school year, group interviews with the children, videotaped interviews with individual children, videotaped observations of the classroom and computer centre, and computer printouts of the children's efforts. For methodological and pragmatic reasons, the researchers chose an agent-central or active role in participating in the classroom.

The findings of the study showed that the creation of a computer-rich environment appeared to serve as vehicle for more general modifications in a teacher's curriculum and methods of instruction, some of which appeared to have little to do with the introduction of technology itself. Conversely, other changes to curriculum and teaching methods were carried out because of the type of available software, its nature and scope.

A second finding focused on the manner in which the Grade 1 teacher was involved in the process of mutual adaptation. Instead of a linear process, it was discovered that the teacher accommodated computers into her teaching in an irregular fashion, perhaps described best as "two steps forwards - one step backwards".

The manner in which children learn from computers through discovery, or incidentally, was the third major finding. As they worked through programs, children appeared to be entertaining or "floating" several hypotheses simultaneously concerning the activity and the operation of the software. These hypotheses often were formed on the basis of "fuzzy" or partial knowledge. Suggestions as to how teachers might foster richer learning on the basis of this phenomenon were offered.

The complex issue of how teachers make computers a natural aspect of their teaching was a major notion studied in the SCL Project. Working from the premise that computers would be viewed positively by teachers only in so far as they could see software serving as an integral and natural aspect of their curriculum and teaching, we carried out observations to determine if such congruence existed. The results were mixed in that ample examples of computers becoming a natural aspect of teaching and learning could be found, however, an equal number of counterexamples were observed as well.

Finally, the report discussed the strengths and weakness of selected software available on the ICON computer and used by children in the study. Examples included intended features designed by authors as well as unanticipated uses by teachers and children.

Recommendations, based on the findings, were made for others who may become involved in creating future computer-rich environments - Ontario Ministry of Education officials, board and school administrators, and, most importantly, teachers. The recommendations focused on the nature of mutual adaptation, understanding learning styles of children, ways and means to support teachers' efforts, and software considerations.

NOTE: ALL NAMES OF TEACHERS, STUDENTS, AND SCHOOLS REFERRED TO IN THIS REPORT HAVE BEEN CHANGED.

The visitors watched carefully as 12 children called up various programs on the ICON computers located in the computer centre of Hampton Elementary School. Moving from one student to another, they observed with interest children working at LOGO, IPAINT, PUTTING YOURSELF TOGETHER, MATH MAZE, and OFFSHORE FISHING. Each child was observed for a minute or two as a member of the Schools, Computers, and Learning Project tried to provide a running commentary as to what a particular child was doing. "Notice the eagerness of the children as they work through the program," the guide said. "Yes," replied one visitor. "But what are they learning?"

Introduction

The scene described here was repeated on numerous occasions during the first year of the Schools, Computers, and Learning Project (SCL). Visitors spent a few moments watching a child work at a computer, and then questioned whether or not anything was being learned. At the beginning of the project, members of the research team also were intrigued by this question. Computers and their accompanying software are a major expense, so it makes sense to have some idea of their value in fostering learning. Fortunately, SCL Project team members were not faced with a situation where instant decisions about the nature or scope of children's learning were required. Our mandate was to study the mutual adaptation of the new technology on a longitudinal basis, where the natural unfolding of teaching and learning could be captured.

As we discovered during the initial period of investigation, the issue of learning is multifaceted and complex. Children learn directly by using certain programs on the computer, and this hands-on learning is valuable. However, growth also occurs through hands-off learning, where children move easily from computer programs to corresponding activities using more traditional materials, and in these latter instances the direct role of the new technology is less easy to document. Moreover, subtle forms of learning, not foreseen by the research team, took on more importance as the project progressed. For example, incidental learning, which initially was not one of our major research goals, proved to be a fascinating web, where older brothers and sisters introduced younger siblings to computer programs not typically used by teachers or students in lower grades, and these children in turn taught their classmates. "The Subculture of

Computers", as we have dubbed it, turned out to be a highly productive teaching vehicle at Hampton School.

How children used computers was one research interest while a second, and equally interesting, issue focused on how staff adapted the new technology to their teaching. Although we documented some of the general uses of computers in the school, our prime goal was to study intensively how one teacher, Sharon Jensen, began to use the new technology in her Grade 1 classroom.

Like children's learning, the issue of teacher adaptation was more complex than originally conceived. For example, the existence of the Schools, Computers, and Learning Project seemed to serve as at least one stimulus for other changes in Sharon's teaching; changes that had little or nothing to do with computers. However, other accommodations in her teaching seemed to be related directly to the introduction of computers into the classroom.

Audience for the Report

The Schools, Computers, and Learning Project was set up to examine the mutual adaptation of the new technology in an elementary school setting. Hampton School was chosen deliberately because the teachers at the school, for the most part, had little experience with computers. Thus, we were observing what happens when a computer-rich environment is created (see Figure 1). In the coming years, many such computer-rich environments will emerge in Ontario and the rest of the world as technology becomes more accessible, and it is important to learn as much as possible about the nature of the various forms of change that may take place in order to smooth the transition for other schools and their staffs.

In crafting this report we tried to be aware of three major audiences - Ontario Ministry of Education officials who are charged with creating policy and provincial guidelines for computer use, school board administrators who must interpret Ontario Ministry of Education policy and implement it in a local context, and, most important, teachers who will be faced with the day-to-day task of using technology creatively and productively as a natural aspect of their teaching.

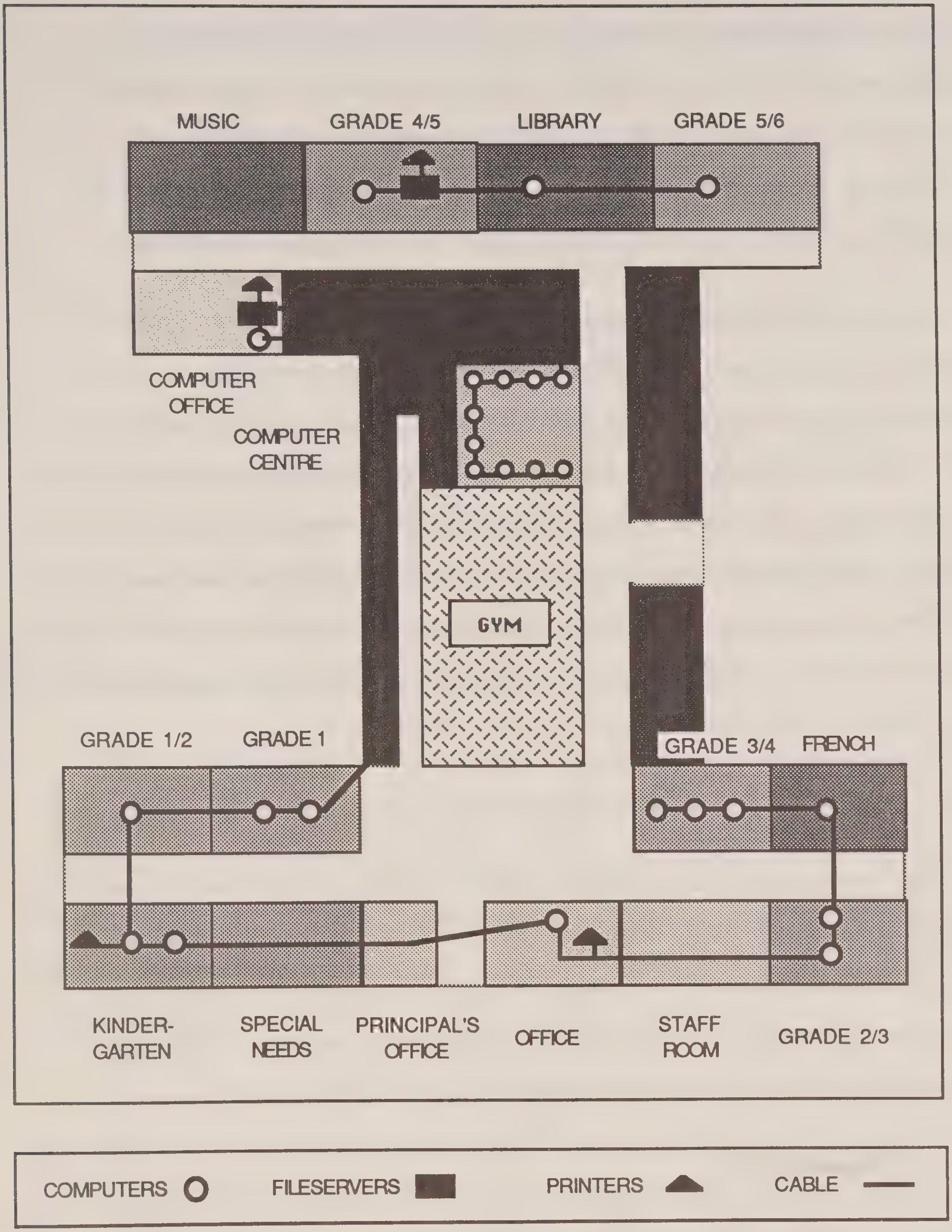

Figure 1. Computer-Rich Environment

The reader should remember that the lessons learned in Year 1 of the Schools, Computers, and Learning Project are fluid rather than static. The path to effective computer use is not linear but organic and interactive. Each school that implements the new technology will encounter problems unique to its context, however, by examining the process of change at Hampton School, readers may understand some of the fundamental aspects of creating a computer-rich environment - the joys as well as the frustrations.

This report, like the others in the Schools, Computers, and Learning series, is unique in that none of the researchers is attempting to 'prove anything' using traditional experimental paradigms. Notwithstanding our proposed research focus, we did not begin the study with preconceived notions of how the year should proceed. To be sure, we wrote this report aware of our theoretical positions, and these positions influenced the topics selected for study as well as how we viewed computer use in the school (see Miller & Burnett, 1986; Miller and Burnett, 1987 for a discussion of how one's theoretical stance may affect computer use). However, none of our observations should be construed as critical of any of the teachers involved in the study. These teachers are honest workers in the vineyard, attempting to make sense of the new technology's place in their teaching, and we tried to portray this quest.

Research Questions

Donald Graves, writing on his landmark study on children's writing, noted that some of the most interesting questions arose only as the investigation unfolded (Graves, 1979). In our work, we devised a set of research questions that appeared sound because of their fundamental importance in discovering more about the computer's role in teaching and learning, however, like Graves, as the study progressed, we abandoned some of our goals, modified others, and added new questions.

The Original Research Goals

There were four major research goals put forth in the initial proposal for our component of the Schools, Computers, and Learning Project. They were:

1. The long-term investigation into writing with computers.

2. The study of a group of children, and their use of computers as they progress through three grades.

3. The study of the transfer of learning.

4. The study of one particular piece of OESS software, THE PUZZLER, and its effect on children's reading strategies.

The first goal was proposed because a great deal of speculation has been forwarded concerning the computer's potential influence on the writing process. Many writers have argued that technology possesses the potential to have a profound, positive effect on children's composing abilities, but these same authors also caution that such salutary effects will not arise simply because students write with computers (Chandler, 1984; Daiute, 1985; Miller, 1985). Although several studies have shown that students writing with computers compose longer stories than when writing with traditional materials such as pencils, the evidence that they write better stories is not as clear (Miller, 1986). Also, little is known about how technology might change the manner in which teachers foster the writing process.

The second research goal was selected because we do not have a clear picture of how teachers and children change over time in the manner in which they use computers. For example, if teachers are unable to find software congruent with their normal style of teaching, do they abandon the software and revert to this usual style, or, do they modify their teaching styles to fit the software? The longitudinal nature of the investigation offered the researchers the opportunity to examine this question as well as other issues related to teaching and learning.

The transfer of learning was the third issue that seemed important prior to the start of the study. Taylor (1980) offered general praise to computers because they possess the potential to serve as tutors, tools, and tutees, and Strickland, Feeley, and Wepner (1987) extended these notions to the area of reading education. However, the nature and extent of computer-based learning has not been documented extensively. Further, most attempts at demonstrating computer-influenced learning focused on the effects of specific programs using pre-test/post-test research designs. While not discounting the value of these quantitative

research designs, the goal in this study was to observe more subtle forms of learning that may occur because of computers. Although qualitative research techniques may not lead to results that are as generalizable as those obtained using quantitative methods, they may capture a useful picture of some of the complex, interacting relationships that occur in the real world of schools (Goswami & Stillman, 1987).

Our final goal was to demonstrate the exemplary use of one specific piece of courseware, The Puzzler, in a classroom context. The Puzzler is a unique package in that it was not designed as a self-contained computer program (Miller & Burnett, 1986; Burnett & Miller, 1984). Instead, the computer-based reading strategy lessons were developed as one component of a total package, where the whole group introduction led by the teacher and a small group follow-up were equally important to the learning. The package also is different from other types of programs in that it offers no feedback as to the correctness of the user's responses and makes no use of graphics, two commonly praised attributes of computer assisted instruction. We planned to create a videotape of the exemplary use of The Puzzler in order to provide in-service education for teachers.

The Modified Research Goals

The computers allocated for the Schools, Computers, and Learning Project were delivered in late October 1987 and set up for use in early November. Due to initial start-up delays, the computers did not receive immediate or extensive use, however, this period of time was used productively by staff for in-service learning, which was conducted each Monday after school. Although the project was in an embryonic stage, it became apparent that our research goals required modification. There were three reasons for these changes. First, the teachers in the study had complete control over how they planned to use the computers. If the computers were not used extensively in one area, for example, fostering the writing process, then it was not possible to observe this aspect of implementation. Thus, we modified our research goals so that they were more congruent with what was happening in the school, not what we thought should happen.

The second reason for modifying the research goals focused on the emergence of previously unconsidered issues. As the study progressed, we began to notice the existence of Hampton School's computer subculture where children were learning about and using programs not introduced formally by the teachers The underground network had an intriguing genealogy, where brothers and sisters would tell younger siblings about a program, and these children would teach their classmates. OFFSHORE FISHING, one of the favourites of the computer subculture, began to attract a steady coterie of users whenever a machine was available. When asked why he liked the program so much, Brent, a Grade 1 pupil, replied, "I like to fish." Studying a group of would-be Issac Waltons may not appear to be an admirable research goal, however, in observing the students, we began to realize that some remarkable forms of learning were transpiring.

The final reason for modifying our goals was time. Placing 27 workstations, along with peripheral equipment such as printers, modems, and synthesizers, into a school whose staff had little experience with using the new technology is a large undertaking, and it became clear that our research time frame would have to be adapted to fit the needs of the staff and other researchers. Because Dr. John Olson was carrying out a demonstration of the exemplary use of FLAME LIFE, we decided to postpone THE PUZZLER component of our research until the second year of the project.

As the Schools, Computers, and Learning Project evolved, we decided to maintain two of our research questions although each was expanded or modified. The first and third questions, which focused on computers and writing and the transfer of learning, were modified greatly, and the demonstration of THE PUZZLER, the fourth research aim, was delayed until the second year of the project as stated earlier. Question 2, the longitudinal study of a class over a three-year period was expanded. Finally, a new goal was added, which led to the following revised list of research goals:

1. The study of a group of children, and their use of computers, as they progressed through three grades of schooling.

This goal remained viable although more focus was attained as we began to observe the Grade 1 class. Children's choices of software, their understanding of the computer and how it worked, and their learning from the various programs became the key issues in the general question.

2. The study of a teacher using computers over a three-year period.

Although one of our original research goals was to follow a group of children for three years, it did not occur to us initially that teachers grow and change as well as students. As we talked with Sharon, and observed her use of computers, it became clear that studying how she used the new technology in her classroom was as important as observing the children. The reports emanating from the Schools, Computers, and Learning Project are designed to help others - ministry officials, administrators, and teachers - in planning for computer-rich environments. Gaining insights into one teacher's use of computers, and how this use changes over time, seemed crucial. Thus, we began documenting Sharon's general use of computers, how she modified her teaching to accommodate the new technology, and interestingly enough, how she generally changed her teaching practices even when computers were not involved directly. Like our study of the children, this aspect of the investigation will continue over a three-year time frame.

3. The study of the computer's role in fostering literacy.

The original research goal of investigating children composing on computers was predicated on a process approach to writing. Frank Greene of McGill University has a questionnaire designed to help teachers evaluate word processing programs that begins, "Do you use a process approach to writing?" Underneath the question it says, "If the answer is 'No ', stop here." Focusing only on word processing in the Grade 1 class was not appropriate. Although writing was an integral aspect of the total curriculum, a process approach, such as that described by Calkins (1986), was not evident. Therefore, we expanded our question to look at the use of computers in the wider context of literacy education. Here, both in the school generally, and in Sharon's class specifically, we were able to describe many creative uses of the new technology.

4. A study of the transfer of learning.

This question was modified in terms of focus. As the study ensued, it seemed clear that documenting the transfer of learning through ethnographic research techniques was as prone to quicksand as using quantitative methods in that it was difficult to attribute learning, and its transfer to new contexts, directly to the computer. On the other hand, it appeared that the computer was providing an environment for learning, perhaps more as a catalyst than a direct teacher, and this learning seemed to transfer to situations outside the immediate computer setting. In our study, we attempted to document this more subtle form of learning.

5. The study of one particular software package, THE PUZZLER, and a demonstration of its exemplary use in the classroom.

As mentioned previously, this goal, while viable, was delayed until the second year of the study.

Research Methodology

All methodologies carry baggage. Isolating variables and studying their effects on learning in a laboratory setting, has value in certain situations, but this form of research often loses its power when the variables studied are put back into a real world context (Rudduck & Hopkins, 1985). For example, the effects of various isolated linguistic variables (e.g., pronouns) on general reading comprehension have been studied frequently, however, real reading is a holistic activity influenced not only by text factors but by factors within the reader such as background knowledge and purpose for reading (Carroll, 1971; Spiro, Bruce, & Brewer, 1980). Thus, one can question whether or not much is learned about the reading process by carrying out studies on isolated variables.

Recently, more researchers are going into schools in order to examine teaching and learning in a more realistic context, and while this form of investigation may be intuitively appealing to many persons in the education field, it is important to acknowledge the baggage accompanying qualitative research methods, especially those selected for this study. For example, as a participant observer, the researcher may

choose to enter as an active or passive participant, and either choice offers certain advantages and disadvantages (Spradley, 1980). Another problem arises when researchers decide whether or not to examine a setting using their theoretical perspective or the practical knowledge of the teacher. Clandinin (1986) described these positions as two ends of a continuum, using the terms agent-free and agent-central to describe the contrast.

We chose to be agent-central, or active participants, for three reasons: pragmatic, methodological, and personal. The pragmatic reason for our choice emanated from initial conversations with Sharon, the Grade 1 teacher with whom we worked, where it became clear that she viewed our participation as active. She mentioned that it would be enjoyable to work with us during the year, and that we probably had many good ideas for using computers. Notwithstanding Sharon's naive trust in our teaching ability, this arrangement matched our personal preference which was to be involved in the classroom rather than act simply as passive observers. Finally, on methodological grounds, we believed that the mutual adaptation of the new technology could be understood most clearly if we were insiders, that is, actively experiencing the use of computers as an integral aspect of teaching and learning.

The procedures we adopted in using the agent-central role follow the work of Clandinin (1986) and Elbaz (1983). Clandinin (1986) stated the agent-central role is characterized by a caring, subjective stance vis- à-vis teacher participants and by methods which highlight the values and purposes of both researchers and teachers in the study. In a manner similar to Elbaz (1983), we attempted to acknowledge our values, theoretical positions, and interests when describing the teachers' use of technology. As well, and especially in Sharon's case, we attempted to capture the teachers' practical knowledge when describing their adaptation of the new technology to the classroom scene.

Although active participant observation was a primary mode of data gathering, other methods were used as well. In order to gain insights into teachers' espoused theories of instruction, background in computer use, and initial view of the Schools, Computers, and Learning Project, each faculty and support staff member of Hampton School was interviewed (Hawes, Egnatoff, Higginson, Miller, Olson, & Upitis,

1988). As described in Hawes et al., these interviews were important as they established the benchmarks for later observations concerning the impact of technology on teaching and learning. Professional staff members only were interviewed again in June of 1987 (Kersey, Egnatoff, Higginson, Miller, Olson, & Upitis,1989). In the present report, use of these interviews was made to establish Sharon's espoused theory of teaching, classroom routines, and attitude toward the project.

Throughout the year, videotapes of the Grade 1 class were made for later analysis. Some of these tapes were created randomly in order to capture the flavour of the classroom as the year progressed; others were made to document special projects where the computer played an important role in teaching and learning. In order to study products, selected copies of children's work were collected in the form of printouts. When these printouts were combined with classroom observation of computer use, they permitted a portrayal of both process and product.

In late April and early May of 1987, each child was interviewed individually by Julia Blackstock, one of the authors of this report. There were two basic formats for these semi-structured, videotaped interviews. Some children were asked to pretend that Julia wanted to buy a computer, but she knew nothing about the ICON. This group of children was to tell Julia everything they knew about the ICON, including any software programs they wished to show her. Other children were asked to pretend that a cousin was visiting Hampton School. In this version of the interview format they were to show the cousin how the computer worked and to demonstrate one of their favourite programs. Each interview took approximately 30 minutes. Although a structured format was used to start each interview, the researcher responded to the children's comments, asking for expansion and clarification when appropriate. The videotapes were analysed by both researchers, working co-operatively, in order to examine such themes as computer knowledge, software choices, incidental learning, the computer subculture, and strengths and weaknesses of existing ICON software.

The Mutual Adaptation of Technology at Hampton School, with Emphasis on Literacy Education

As stated in the methodology section of this report, readers need to understand the researchers' theoretical perspectives in order to interpret their descriptions of how teachers at Hampton School adapted technology to meet the needs of the children, and, as well, how the teachers adapted to the technology. There is no attempt made in this report to explicate fully our view of all language processes and how they are acquired. Instead, we focused on two aspects of literacy, reading and writing, which are viewed frequently as those most influenced by formal schooling.

A Model of Reading: Process and Practice

Theories and models in literacy education should not be treated as isomorphic with those in the sciences; instead, as Pearson and Kamil (1978) pointed out, they act as metaphors, where practice can be compared with one's understanding of process. Also, models of how print is processed, especially by adults, should not be confused with a description of reading acquisition.

Like Rummelhart (1977), we believe print processing is a constructive, problem-solving act where the reader uses a variety of cognitive strategies to apprehend the meaning of a text. These strategies may involve graphophonemics, syntax, semantics, and pragmatics. But to carry out the task of understanding print, readers must use knowledge within the mind as well as information provided by the author. Rummelhart's model is referred to as interactive in that it credits the contribution of prior knowledge as well as the use of processing strategies.

What does such a model of the reading process imply in terms of practice? Clearly it means that teachers must foster a variety of reading strategies, not simply the skill of decoding as argued by authors such as Englemann and Bruner (1974). Processing models do not imply necessarily how teachers should go about fostering various cognitive strategies, however, some teaching techniques, ways of responding to children, and materials would appear to be more congruent with certain models. For example, in the

Rummelhart model (1977), the prior knowledge a reader brings to the print is an important determinate in comprehending a text, therefore, a teacher might decide to carry out prereading activities designed to build appropriate background knowledge, or schemata, for later reading. No particular activity is prescribed by this model, and the teaching could take the form of a movie on the topic, a field trip, or a class discussion, each carried out prior to reading the text.

We believe a total communication or whole language approach is best suited to the Rummelhart processing model although other research, such as Harste, Burke, and Woodward's (1984) work, which described the developmental nature of literacy acquisition, is equally influential in making this judgement. Moreover, in describing our orientation to instruction as one of whole language, we are reminded by Newman's (1985) caution that there is no such thing as 'the' whole language approach. Rather, whole language is simply a term representing a set of tenets about how language is acquired which are combined with corresponding principles that may guide instruction. Rich (1986) succinctly described some of these instructional principles; more complete descriptions can be found in Cochrane, Cochrane, Scalena, & Buchanan (1984), Goodman (1986), Goodman, Smith, Meredith, & Goodman (1987).

Writing: Process and Practice

Unlike the reading field, where there are many competing models of how the mind processes print, few authors have tried to develop models of the cognitive processes involved in composing. An exception to this generalization has been the work of Flower and Hayes (1980). However, in recent years, there has been a plethora of research describing how writers go about the composing act, and this research has examined age groups ranging from preschool children to university. Donovan and McClelland (1980) recently described just a few of the various models and approaches to composition instruction.

Graves' (1983) description of a process or studio approach to writing instruction, which was expanded upon by Calkins (1986), is a useful touchstone for portraying our view of how instruction is derived from an understanding of the composing processes of children. This approach, based on a longitudinal study of children's writing (Graves, 1981), is relevant to this study in that it addresses specific

techniques, classroom routines, and teacher attitudes designed to foster the composing process. The principles of composition instruction advocated by Graves form the basis for our theoretical perspective on this issue.

Graves (1981) proposed a five-stage model of writing - prewriting or rehearsal, writing, revising, editing, and publishing. This is not a stage model in a Piagetian sense, instead, Graves viewed it as a teaching format, one that seems to model the processes professional writers engage in when composing. The five-step model is not meant to be a cookie-mold for instruction where each piece of writing must flow through the five stages equally. As Graves (1981) pointed out, "Behaviors of writers are idiosyncratic and highly variable." He argued further that, "...such variability demands a waiting, responsive style of teaching."

Giacobbe (personal communication, 1983), adding to Graves' notions, stated that writers need three essential ingredients - time, ownership, and response. Following Giacobbe's contention, we believe a productive classroom setting would allow time for writing throughout the day and curriculum, permit children to select most of their own topics, and offer numerous opportunities for sharing. The pupil/teacher relationship in such a setting would resemble that of master and apprentice. Thus, such teacher skills as conferencing with children about their writing would take on added importance.

Program Development and the Real World of Schools

As mentioned previously, our view of language processes and vision of derived practice provide a filter for interpreting the use of technology in literacy instruction. Balancing this view from the outside is the actual use of technology from the perspective of a teacher's practical knowledge, or teaching in action. Teachers do not have the luxury of working only from an espoused theory. Their pedagogy is tempered by the demands of the real world of school. For example, it may be theoretically sound to provide a sustained period of time each day for silent reading, where children would select a book of choice. However, the reality of the classroom means that fire alarms, fluoride treatments, school plays, and other distractions vie for this same time.

The reading example described above is similar to the situation encountered by the teachers in this study who were attempting to adapt technology to their teaching. From a theoretical perspective, teachers may want children to use a word processor in the composing process, and producing hard copy of stories is a natural aspect of writing. Unfortunately, if only one printer in the school is operating, it is difficult to fault teachers for failing to carry through with this component. As we described the teachers' use of technology in the SCL Project, we attempted to account for these real world situations.

Sharon's View of her Reading Program

We made no attempt in this report to describe fully all aspects of Sharon's espoused theory of teaching and learning. Instead, we selected one area of focus - reading - in order to show the reader Sharon's vision of how she taught this component of the curriculum. This description, and it is by no means complete, served as a useful touchstone for looking at her theory in action, especially as it took into account the role of computers in fostering literacy.

In the initial interviews, teachers were asked a series of questions designed to elicit their espoused notions of teaching and learning as well as how they viewed the SCL Project. As described in Hawes et al. (1988), Sharon indicated she was a teacher in flux. While it may be argued that all teachers constantly modify their teaching, Sharon's observations are important because she articulated awareness of some fundamental changes in her approach that went beyond the mere selection of techniques or materials. Moreover, she seemed aware that her state of flux was producing contradictions. For example, Sharon stated, "Well, I'm really quite structured actually", but this direct statement was tempered by her observation that it is important to be flexible within a structured environment.

Although Sharon used basal readers for many years, and considered herself a good basal teacher, she believed she was making increased use of thematic units, language experience, the Read-along television program, and, as well, more incidental learning through social interaction. Reading groups, which previously were organized on a homogeneous basis, have given way to more heterogeneous structures. Although the newer activities and learning formats seem to indicate a teacher who is moving on the

continuum from a teacher-centered to a child-centered approach to literacy, such an easy assumption is misleading because Sharon, as she noted, always included reading aloud to children and free-choice, silent reading as part of her overall program.

Sharon was unsure as to how she would incorporate the ICON computers into her reading program because the content of most software was unknown at the time of the initial interview. However, her aim was to integrate the computers completely into the normal curriculum. At this stage of the SCL Project, she assumed that software, congruent with notions of literacy development, was available.

We believe this initial interview is important because it demonstrated a situation other educators will face in creating computer-rich environments. Teachers enter such situations with expectations, and one of these expectations is that software, congruent with normal teaching approaches, is available. Whether or not outsiders such as administrators or computer consultants think the software is appropriate is not as important as the teachers' views. If they do not find software that matches their needs then several options exist. At one extreme, teachers may simply abandon the use of computers or relegate them to minor roles in their teaching. At the other end of the continuum, it may be that teachers will modify their teaching to match the available software.

We cannot place a value on either of these options, or the myriad of possibilities that lie between the extremes. If teachers are highly successful, why should they abandon their usual methods simply to say they are using computers? But, if they are swayed by the values of technology, then perhaps modifying one's program in this direction may be equally acceptable. We believe persons responsible for the implementation of the new technology should pay close attention to a teacher's usual approach to learning. Once this is established, resource persons can help teachers see possible uses of the available software. For example, a teacher who normally sets up mailboxes for the children, and who encourages correspondence among children, may find the possibilities of electronic mail intriguing. Another teacher, who frequently carries out scientific experiments in the classroom, may discover that an OESS program such as **FLAME LIFE** fits appropriately into one of the planned units for the year.

Because the computer can serve as a catalyst for change, a balance should be struck between showing teachers software congruent with their approach to learning and software that can extend the boundaries of their thinking. An example of this latter principle was seen in the SCL Project when Gaye Beckwith, the computer consultant attached to the school, demonstrated MICRO NEWS, an ICON-based software program designed to help in publishing a school newspaper. At the time of the demonstration, none of the teachers in the school was publishing a school newspaper, thus, the program was not congruent with normal teaching procedures. However, as Miller (1987) argued, a school newspaper can be an excellent vehicle for purposeful writing, and its creation is compatible with a process approach to composing. By the end of the SCL Project's first year, a school newspaper had been published. That's the good news. The bad news is that the project was carried out exclusively by Gaye Beckwith, the computer consultant.

We are not discouraged by the lack of teacher involvement in the newspaper project. The other teachers may have been involved in equally useful, but different, projects at the time Gaye demonstrated MICRO NEWS. Or they may have thought that Gaye wanted to carry through with the paper by himself. Another viable explanation is that the teachers needed time to incorporate the creation of a newspaper into their normal routines. In the second year of the project we may see more teacher use of the program, and, if so, such use would be a good example of technology influencing fundamental changes in teaching. As the title of the SCL Project implies, the mutual adaptation of technology is a two-way street.

Sharon's Reading Program in Action

> Three children, early arrivals who are bending school rules, peek into Sharon's room asking if it is okay to sit on the rug and read. After a quick admonishment about early arrivals, Sharon says that they may find a book and read quietly. Even though she has a couple of last minute chores, Sharon takes time to help Bonnie find a book.

As the work of Davis (1982) showed, one should not accept naively a teacher's espoused theory as a direct indicator of theory in action. Although it is possible for teachers to paint a glowing, but unreliable, picture of their day-to-day teaching, Sharon seemed to show an opposite characteristic. From

our perspective, her program appeared far richer than described, at least in a whole language context. Like most real programs, however, it showed inconsistencies. Based on our visits, we observed the implementation of many espoused practices such as reading aloud to children as well as the use of commercial activities to reinforce reading skills, but we noticed also a teacher whose techniques, materials, and attitudes toward children fostered literacy in ways not made manifest by her words.

In the morning children entered the room chatting with classmates. They gathered on the rug, often selecting books from a large classroom selection for silent or shared reading (see Figure 2 for classrom layout). Books read aloud or related to a current theme or project were placed on a special bookcase with ample room for display. Opening exercises included songs, the Lord's Prayer, and O Canada. Afterward Sharon went to a large calendar where children found the day and date. This information was used to start a group language experience story that was subsequently transcribed on the chalkboard. The story, elicited from the children, served as a vehicle for focused word identification study as well as choral and individual reading. Children then were shown the learning centre activities for the day, and necessary instruction for the centres was given. Sometimes Sharon moved to a centre to work with one group while on other occasions she circulated among the children, working with those in need of help.

After recess, those children who completed the tasks at the centres were allowed to select free-choice activities, and one of these choices was the computer. Others finished up the centres although Sharon planned the morning so all children were permitted some free-choice activity. Her teaching style was to continue circulating among the children, discussing their activities or helping with child-selected projects.

In the afternoon, one of the prime focuses was mathematics although both music and French also were scheduled into this time. Teaching formats included manipulative activities developed to teach the concept under study, work sheets designed to reinforce math skills, and games used to teach notions such as number sequence. If a theme or project was in progress, the math frequently was integrated into the unit. As in the morning, some afternoon time was reserved each day for free-choice activities.

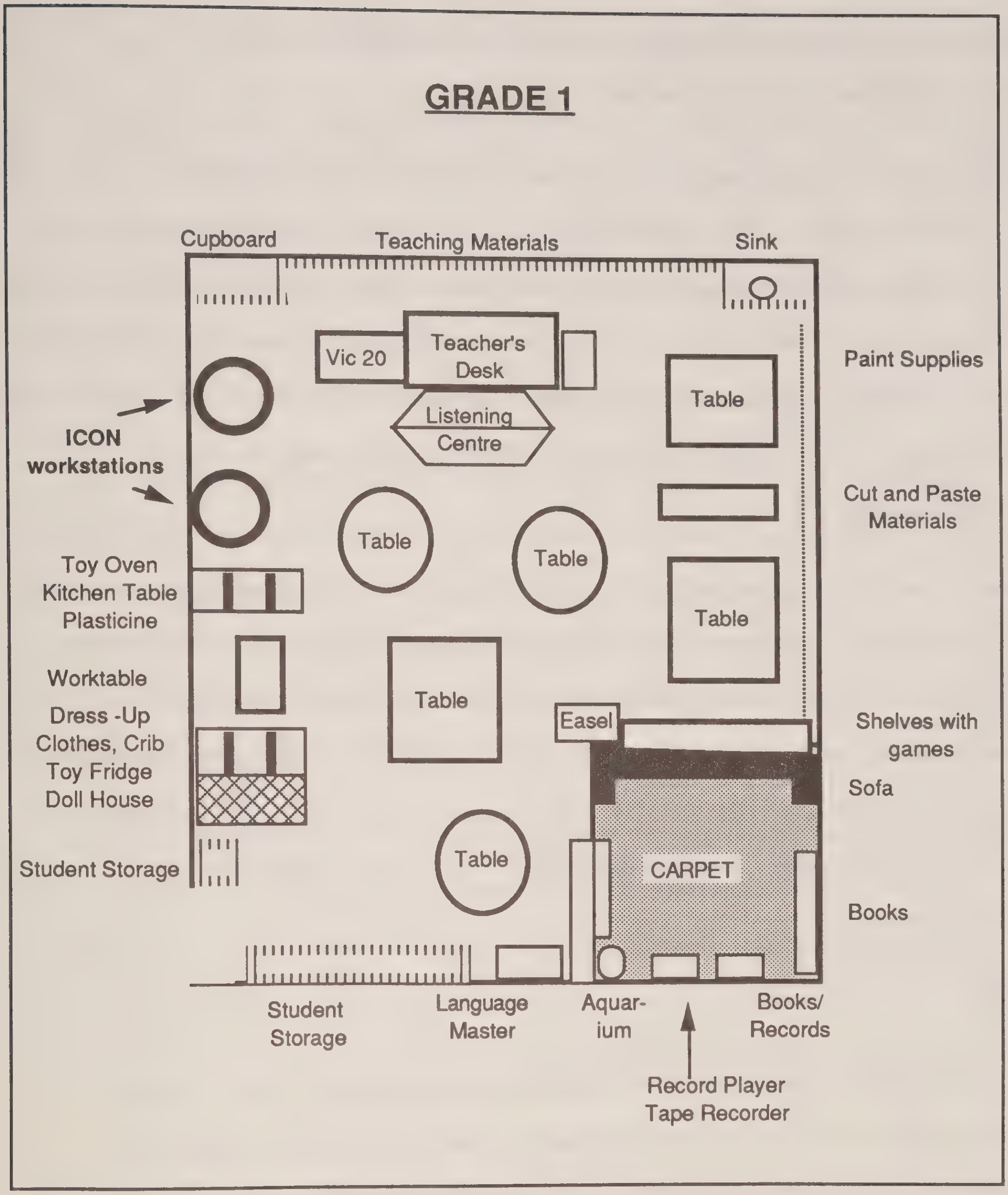

Figure 2. Classroom Layout

This sketch provides a glimpse of the classroom, but it captures only the surface structure. Deeper insights into the true fabric of the room are missing. For example, absent from this portrait is the value placed on talk in the classroom. Throughout the day, children talk readily among themselves and with the teacher. As Tough (1979) demonstrated, teacher talk can be a strong guiding force in learning, but talk

among children is equally important. The work of Britton (1970) and Barnes (1969) documented learning taking place through children's talk, even without the presence of a teacher.

Another aspect of learning not described in the portrayal of Sharon's teaching was the depth and breadth of the free-choice activities. Sharon's room was well supplied with books, two listening centres, a make-and-take centre, a giant play house, a film-strip centre, large puppets, puzzles, games, and computers. On any given day one might observe three children at the front of the room using imaginative language at the house centre, others painting and perhaps telling narratives about their pictures, and still others using free-choice time to explore the IPAINT computer program. In each setting, exploration, expression, and communication transpired.

When thematic units or special projects were being carried out, the schedule, activities, teaching formats, and materials often would be different from those described above in the typical day. Here, the activities with a subskill orientation seemed to be subsumed because of a more holistic approach to the topic. During the themes, the 'doing' aspect of learning seemed to dominate. For example, during a theme on the community, children created a giant map of the neighborhood where each child's house was labelled. Sharon made no attempt at teaching such skills as map reading, legends, or spatial location: the emphasis was on learning by doing.

Summary

In one way, Sharon's espoused theory of teaching reading as well as her theory in action represent the type of balanced or eclectic program advocated by Spache and Spache (1986), that is, a program that draws from the tenets of both holistic and subskill views of instruction. Sharon's theory in action tended to be consistent with her personal view of how she goes about teaching. What we found fascinating was her awareness of a current state of flux. While she was mulling over both the why and how of a more holistic approach to literacy, and indeed implementing some of its principles, Sharon recognized clearly that she has been happy and successful with her more teacher-led, structured approach. We found her candidness refreshing and important because the SCL Project seemed to play a role in this flux.

Sharon's Use of Computers

In describing Sharon's use of computers we opted for selective rather than exhaustive portrayals. Our descriptions are designed especially to highlight some important aspects of computer adaptation that will be analysed in the next section of this report. These aspects include: (a) the manner in which computers are employed, (b) software selection, and (c) adaptation of the technology to the curriculum. Although the focus of this section is on the teacher's use of computers in the early stages of the project, the children's reactions are woven in as well because they are the ultimate consumers of the technology.

It is instructive to remind the reader that most of the teachers in this study did not possess great experience in using computers when the study began. In Sharon's case, she was not familiar with any of the programs available on the ICON prior to the installation of the computers in Hampton School. Thus, Sharon was not only becoming acquainted with the programs on the ICON - their goals, instructional formats, and potential uses - she was also learning about the hardware and peripheral equipment. Procedures, which later would become automatic, required time to learn.

We believe that other schools creating computer-rich environments should understand the necessity for time in learning to use both hardware and software. Even though the computer resource teacher, in cooperation with the staff, instituted weekly in-service meetings, familiarity with the technology came gradually. Moreover, use of the computers was punctuated by a phenomenon we came to describe as 'two steps forwards, one step backwards', a trait which will be discussed in more detail later in the report.

Sharon attended all the in-service meetings on the ICON and its software, a sign of her interest in using computers effectively. As one might imagine, these meetings influenced her use of the ICON in that as she comprehended the goals and format of a program, she began to use it in the classroom. Perhaps in an ideal world, it would be useful for teachers to understand fully all aspects of computer use and software features prior to implementation in the classroom, however, the manner in which Sharon came to understand technology probably is similar to how most teachers will learn. Indeed, it may be desirable for teachers to try out programs as they become familiar with them.

Except for the weekly staff in-service meetings, we did not observe Sharon, or any of the other teachers, learning about computers in a structured, systematic manner. Instead, as mentioned above, she learned about a program, tried it out with the children, and then seemed to reflect on its value and place in her curriculum. For example, LEARN TO COUNT was one of the first programs used by Sharon, but its use diminished as she began to question its value, and the children seemed to echo her belief as they seldom called it up during free time. Sharon thought the time expended in calling up the program and working through it was excessive. Moreover, she believed her normal activities carried out the teaching function better than the computer program, an instructive insight.

On the other hand, both the children and Sharon immediately accepted the IPAINT program, using it on a continuing basis. Creating pictures and writing sentences about them was a natural aspect of Sharon's curriculum, accomplished using a variety of media, so a place in the curriculum was found for this computer program. Throughout the year, Sharon would take groups of children to the computer centre where they would create pictures, usually related to a current theme under study, and with the teacher's help, write a sentence or two about the picture. During free time, children frequently called up the IPAINT program, sometimes creating pictures and simply erasing them.

Differences in use of the IPAINT program pointed up interesting aspects of how teachers and children perceive an activity on the computer. Many of the children would work up to 20 minutes on a picture. Then, without even taking time to admire the piece, the child would erase the screen and begin a new picture. It seemed that the process of creation was the intriguing facet of the program to children. On the other hand, when Sharon or any of the researchers worked alongside the children on the IPAINT program, the focus was on writing a story about the picture and printing the product for display.

If some children tend to see drawing and story writing more in terms of the creating process rather than product, the computer is an accommodating vehicle. In traditional settings teachers tend to admonish children who begin a picture or story only to abandon it a short time later. The cost of paper and art supplies probably is one reason; another may be the idea that once a project is begun it must be seen

through to completion, an educational manifestation of the Protestant work ethic. We have evidence that young children like to 'play' at the composing process (Coe, 1987), and the computer accommodates this tendency.

During the first few months of the project, Sharon tried several of the ICON programs with the children, including IZZIT, PUTTING YOURSELF TOGETHER, LEARN TO COUNT, and STORY MATE. The format for introducing programs was to break the class into two groups, with the first group accompanying Sharon to the computer centre and the second group remaining in the room to work at the learning centres with another adult such as a parent volunteer. Programs typically were introduced in a sequential manner with necessary commands and steps explained by Sharon and carried out by the children. Sharon believed this mode of introduction was the most efficient. Once children learned a program they often used it as a part of a larger lesson on the topic.

After approximately three months, Sharon became somewhat discouraged because of a perceived lack of software that matched the level and interests of her class. Too often the directions for a program seemed too difficult for the children to read, or the concepts taught by the program appeared too sophisticated for the Grade 1 students. Especially frustrating was the lack of software that was congruent with the normal happenings in the classroom. This trait was noted on several occasions when Sharon would tell us about an activity she had planned. Frequently, the discussion would end with Sharon asking, "Do you know of any software on the ICON that would help with this?"

On one occasion, Sharon created a special math activity using the STORY MATE program. Although she did not write a software program in a technical sense, her effort was notable for three reasons. First, it marked the first time Sharon used the computer as a personal tool. Second, she tried to alleviate the perceived software shortage by taking the matter into her hands. Finally, after the activity was written and completed by the children, she realized how much work was involved in devising and creating a software program. These types of initial attempts, which might be dismissed by experienced computer users, must not be undervalued as they are part of the road of spiral growth in understanding the uses of technology.

Sensing Sharon's frustration with the perceived lack of software, one of the researchers, Larry Miller, offered to carry out an activity with the class that used the computer. Using the pattern book Spilt Milk, he devised a lesson that involved reading the story aloud and brainstorming as prewriting activities, using both standard media and the IPAINT program to create cloud pictures, and, finally, writing accompanying stories for the pictures. Because the children used both standard media and the computer program to write their Spilt Milk stories, a comparison of the process and product of each was possible. Interestingly enough, we observed no differences in either process or product as the children seemed to enjoy and work well with both creative forms, and the products - pictures and stories - were equally inventive.

In the ensuing months, two more pattern books were created using the IPAINT program as well as traditional media forms. Further, some of the children began creating books of their own during free time. Sometimes the creation process involved copying from books such as The Hungry Caterpillar while on other occasions the children devised original pieces.

Critics of computers in the schools may wish to use some of our observations concerning no observable differences in learning modes to support their contentions about the value of technology in schools, especially given the cost. However, in our opinion such a view is narrow. Technology's usefulness cannot be judged on the basis of one activity. Further, such a judgement excludes the incidental learning that occurs when children use computers. Indeed, as we will argue later, incidental learning may be one of the most powerful forms of learning fostered by technology. Our caution is simply one of reasonable expectations and a broad vision of technology's place in learning.

As the year progressed, Sharon and her class began to use the computers in a regular manner, and routines developed. Over time, children were introduced to programs Sharon believed appropriate for a Grade 1 class. Thus, by the middle of the winter semester of 1987, the children had been taught to use such programs as IPAINT, LEARN TO COUNT, STORY MATE, and IZZIT. Interestingly enough, during computer free time, the children were calling up and using additional programs, ones that had not been formally introduced in class. Although we had observed this phenomenon almost from the beginning of the

Affective Learning: I Like to Fish

Given our prior observations of the computer subculture, it did not surprise us that several children selected OFFSHORE FISHING as their demonstration program. However, other programs selected proved equally useful in documenting the scope and types of knowledge gained in using forbidden fruit. In this report, we focused mainly on the OFFSHORE FISHING program because it seemed to provide exemplars of the types of learning that occurred when children worked through a program identified as forbidden fruit.

Before examining the cognitive aspects of children interacting with OFFSHORE FISHING it is instructive to examine some of the affective dimensions of learning the program stimulates. With few exceptions children became excited when showing us the program or discussing it during the interview. Jason delved into the core of why most children liked the program by saying, "Because you can catch fish." His straightforward answer was echoed in various ways by other children, and it turned out that most of these children liked to fish in real life.

It was common for children to become so involved in the program that the researcher interviewing them was ignored. One child, upon seeing the shrimp icon at the bottom of the sea, exclaimed, "Oh shrimp! I love shrimps! I wish this was really shrimps! I wish I was really on that boat!" And at times, the children's genuine frustration at being 'skunked', as fishingfolk put it, was made manifest. Consider this monologue by Gregory:

> I can't believe it. I can't catch it. I am going somewhere else
>
> where there's better fishing.
>
> (later)
>
> Boy, this is not my day!

Children seemed prone to blame their difficulty on the vicissitudes of fishing rather than their abilities as learners. As Matt put it, "...probably not the best day for fishing."

The most poignant example of involvement came from Dallas, a weak academic pupil but an avid, reasonably skilled user of OFFSHORE FISHING. Dallas was dragging for lobster and shrimp during his interview with one of the researchers. After several unsuccessful attempts to catch some crustaceans because of broken nets, Dallas became even more intent. Creeping up behind them ever so carefully he whispered, "Lobster! Better not ruin my net again! Little bugger, I'm not letting you get it this time!"

The devil's advocate could argue, "So what? Children might become equally excited about video games at the local arcade." The section on the cognitive values of programs such as OFFSHORE FISHING will answer some of the "So what?" questions, but the merits of the affective dimension of learning possess independent strength.

We noticed that children using OFFSHORE FISHING had a propensity to relate numerous stories of real world fishing trips, often spontaneously. Teachers could use this touchstone to stimulate writing, perhaps in the students' daily journals or in narratives. Or, based on the interest generated by OFFSHORE FISHING, an entire thematic unit could be developed around the topic of water, perhaps in the mold of the fire unit developed by John Olson and the junior level teachers at Hampton School (see Olson and Pothaar, 1988). For years, teachers have observed primary children's fondness for certain topics such as dinosaurs, "all about me", and friendship, and the genesis of much of the "theme" work in primary classrooms has been the desire of teachers to generate curriculum out of children's interests and knowledge. In this instance, teachers could observe children's keenness for the topic of fishing as they worked through the computer program, and by expanding the general notion, a creative thematic unit on water or the seas could be developed, one that included the use of technology as a natural aspect of learning.

Cognitive Learning: Floating Hypotheses and Fuzzy Knowledge

Although some readers of this report may accept the affective values of Grade 1 children working through a program such as OFFSHORE FISHING, others will suspend judgement until they are convinced of the cognitive implications. As we observed children demonstrating their understanding of the nature and operation of OFFSHORE FISHING, two overriding notions developed. First, children appeared to be

entertaining and testing several hypotheses at once. Second, as children discussed various aspects of the program, they demonstrated partial or fuzzy knowledge of concepts, terms, and actions. It was floating in the sense that sometimes a child, when asked, seemed unaware of a certain concept, such as the connection between the colour of the legend and the depth of the sea water, and yet moments later might volunteer a theory or comment predicated on that same concept. The act of questioning, though open-ended, may have been responsible for causing the child to make the connection. If so, it speaks well for the potential of subtlety when teaching and learning with simulations.

Emily, a Grade 1 pupil in Sharon's room, was one of the children who selected OFFSHORE FISHING to show the researcher during the individual interview. As she worked through the program the notions of floating hypotheses and fuzzy knowledge became manifest. Although we selected Emily's protocol for the analysis presented here, protocols of other children are referred to as well.

Emily: A Case Study

Once OFFSHORE FISHING was called up, Emily had to choose which of three goals she wanted. She selected Game 1 because, as she put it, "It's easy." The program then required her to choose a season in which to fish - summer, winter, or summer and winter alternately. Taking on the role of gracious host, as several children did, Emily politely asked the researcher which season she preferred. When encouraged to make the choice, she responded, "I like summer cause in winter you can't get around [sic] much fish." Here Emily revealed the first of her hypotheses about the simulation, that is, the season one selects has an affect on the abundance of fish caught.

Emily wasn't alone in entertaining ideas about the effects of the season selected. And although we found no consistent pattern in the hypotheses, children who talked about the season did so in the context of selecting the best time for fishing. Some children formed assumptions that were more interesting than accurate. Gregory, for instance, believed that "Summer has soft ground in it." This notion isn't quite as mysterious as it may seem as the type of ground under the sea turns out to be an important variable in

terms of the number and type of fish found in an area. From an adult perspective, the only misconception he held was that there was a direct link between season and type of ground.

Like many of the children we observed using the program, Emily had difficulty exiting from port without grounding the boat. Interestingly enough, Emily formed a correct hypothesis when she told the researcher that the boat had to taken out with care so that it would not touch land. Unfortunately, her manual dexterity with the trackball was not at the same level as her mental dexterity. Some of the other Grade 1 children did not seem to share Emily's understanding of leaving port. These children tended to adopt a 'bull in the china shop' approach, and sometimes had to begin again seven or eight times. Children who formed the hypothesis that you had to be very careful in leaving port tended to move the trackball very slowly.

On the first of her three accidents, the screen flashed a message that explained that one of the consequences of grounding was the loss of all fish previously caught. Emily thought this situation needed explaining and said to the researcher, "We didn't really lose all our fish, but they call it losing all your fish because you just started." Emily knew that she could not have lost any fish without having first caught some, but her explanation revealed an acceptance of the arbitrary nature of computer messages. Emily went on to read the message. "You've lost 30... (Emily pauses). She could not identify the next word, and the complete message could have added to her understanding of the consequences of her actions, however, the inability to read the entire screen did not deter her from proceeding.

As the boat left the port, Emily was faced with a large colour-coded map (see Figure 3). The colours indicate the depth of the water. On the right-hand side of the screen are several legends, one indicating water depths for the colours. Students using the program must make a decision as to where to fish. Emily immediately headed for shallow water saying, "Here's where you can get the mostest [sic] fish." It was unclear at the time whether or not she meant that particular spot on the map or all light-coloured areas. What is clear was that she had formed a hypothesis as to the location of the local 'hot spot'.

After a couple of delays, the researcher asked Emily about her choice of location because she continued to return to it. "Because you can get a space there where you don't lose all your fish and have to return sometimes," she replied. She meant return to port, a requirement if nets are broken. Again, we observe that Emily has formed a hypothesis about how the simulation is played. From an adult view, it is obvious that Emily's hypothesis is an incorrect generalization of a correct observation, but that's not the point. Hypotheses are meant to be tested, and Emily has a testable hypothesis. As she continues to play the simulation, she will undoubtedly discover that other locations on the map yield similar opportunities for fishing.

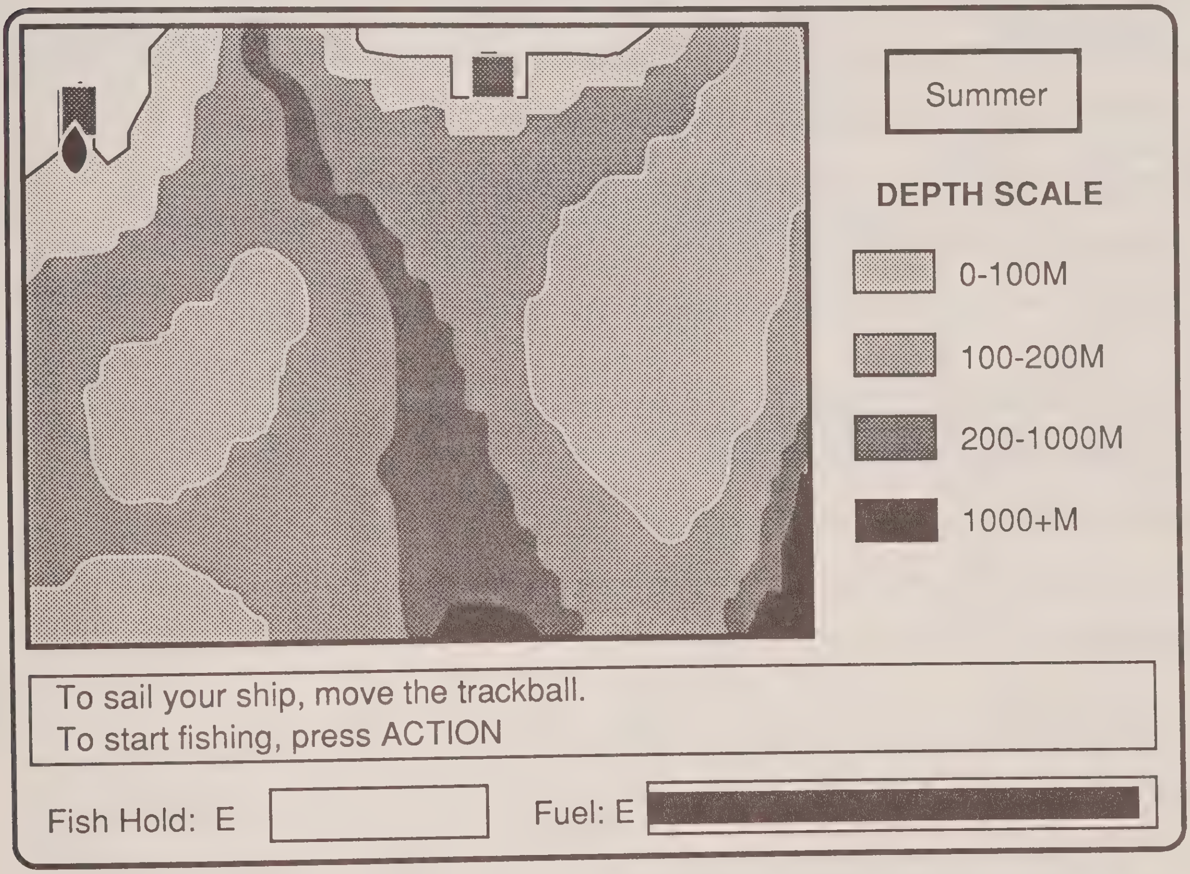

Figure 3. OFFSHORE FISHING - The Map (facsimile)

While waiting for the next screen, the researcher asked Emily about the significance of the different shades of blue that indicated varying water depths. Emily showed partial or fuzzy knowledge in that she knew one could fish in each of these areas, and she was aware that corresponding colours were displayed on

the legend (see Figure 3). "You can go fishing in black, blue, this kind of blue or just plain blue or that kind of blue I just went to," she said. However, she had not yet made the connection between the legend and map. Other children in the class also were aware of the legend, and the information contained in it. Some students had made the proper connection and used it to aid their fishing expeditions while others simply knew it existed.

Emily then used the <search> command which set in motion a simulated sonar search and watched while the sound waves swept through her choice of location. The sonar reveals both the nature of the sea bottom in terms of hardness as well as showing the icons for various types of fish and crustaceans. A legend located on the right of the screen displays the icons beside the name of the fish or crustacean. As she watched, Emily spontaneously explained the action of the sonar by saying, "You call some fish. It's not high ground, but it might be rocky. Sometimes you get the redfish or the bluefish." As she enlightened the researcher, Emily pointed to the legend. Emily was only partially correct. The legend contains redfish but not bluefish. Nor does it contain a crab although the lobster icon does resemble a crab.

Emily continued, "The crabs are hard to get because they're too low down. You gets lots of crabs sometimes and sometimes there's really high ground, about that high," she said pointing to the screen to demonstrate the depth. Although her terminology is somewhat off, Emily does have a partial understanding of the type of fish she is about to catch. Moreover, she has constructed a hypothesis to explain why crabs are difficult to catch.

Emily's application of the concepts of high and low ground to describe what would normally be referred to as deep or shallow water deserves comment. The habit of describing conditions at sea in terms of the depth of the water may come from fishing and the perspective of the fisher, on top of the water facing downward with the sea bed acting as a physical boundary. If Emily's language was unusual so was her visual perspective. The screen at which she was looking contained a cross-section which showed the sky, sea surface, sea, and lastly the sea bed (see Figure 4). A view such as this is an artificial construction - the sea bed, for instance, is not simply the physical boundary; it is an integral part of the cross-section. It is

not surprising then that Emily should have chosen to pick the sea bed as her point of reference and used attributes that related to ground.

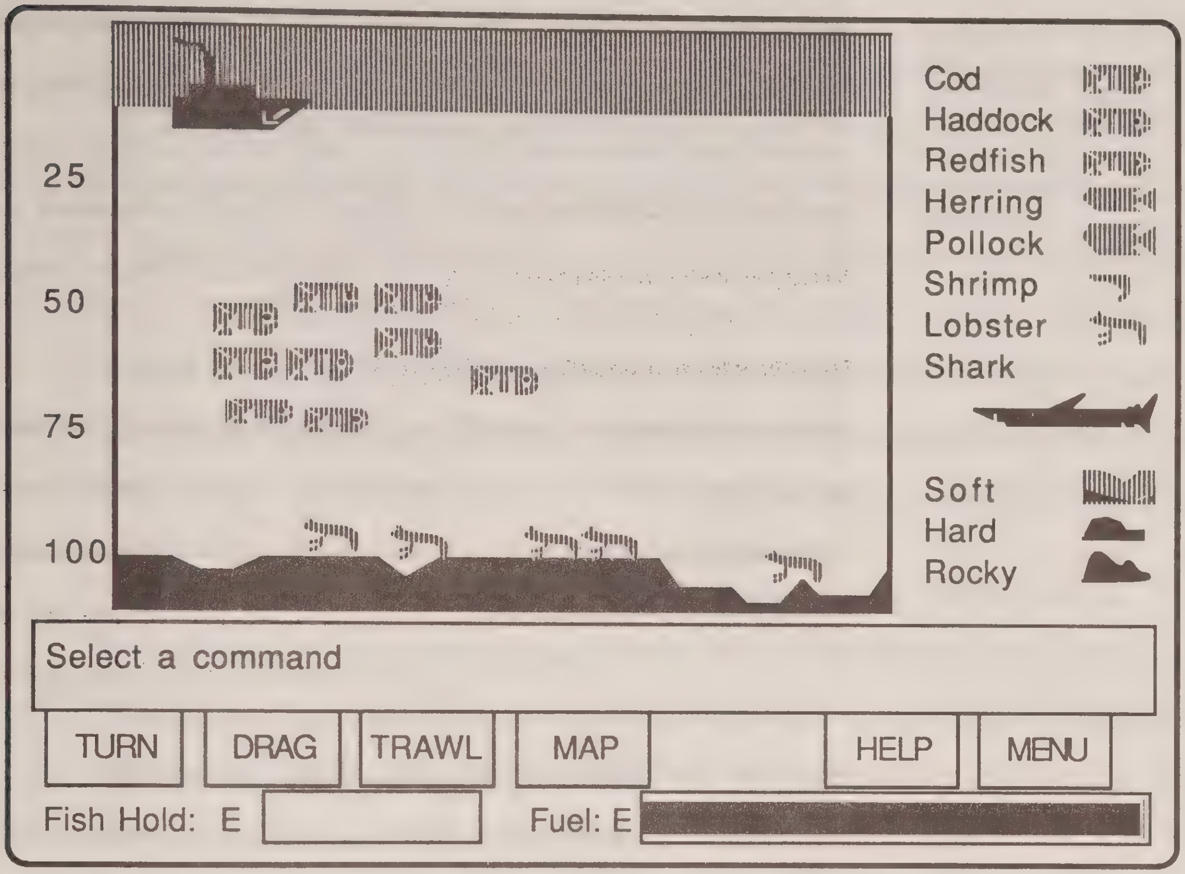

Figure 4. OFFSHORE FISHING - The Cross-Section (facsimile)

At this point, Emily was distracted from the conversation, and pointed to the screen and commented, "Well, you notice that it blinks because, ...(pause). Well, I don't know why it blinks. At the bottom it blinks because...." Emily's voice trailed off. Interestingly enough, the researcher also noticed the screen had blinked, but she wasn't aware of the reason either. In the meantime, Emily had come to a conclusion about the cause of the blinking screen. She pointed with excitement at a school of fish visible on the screen and proclaimed, "Yeah, that's how they move." Emily was correct. The program was designed to simulate the movement of fish by reloading a screen identical to the last one, except for the new position of the school of fish, much in the same manner in which cartoons work. We don't know the

nature of the hypothesis Emily was working on when she first observed the blinking screen, but she clearly came to a (correct) conclusion as more data became available.

As Emily maneuvered her net, she commented, "Yeah, we're going to catch some lobster first, but be careful not to make your net break." Without hearing any reference from the researcher, Emily had suddenly replaced the word crab with the correct label lobster. We frequently observed this phenomenon, perhaps another example of fuzzy knowledge. Emily may have used the term lobster correctly on other occasions and may simply have required time using the program before she activated her store of accumulated information on OFFSHORE FISHING. Or, perhaps, she had simply noticed the legend on the screen, looked for the accompanying word and read "lobster." Interestingly enough, Emily was not the only child to follow this pattern with crabs and lobsters.

Returning to Emily's comment about the net, the researcher began to probe for her hypotheses concerning the causes of net breakage. She, however, was preoccupied with the task of catching fish. She ignored screen messages indicating the net was about to break. Even though Emily is a good reader, she seemed intent only on the task of fishing. When it broke, Emily did not appear upset when she announced the event aloud. This time when asked why the net broke, she responded, "Well, your net breaks from keeping it in water too long." Emily wasn't alone in having a hypothesis about torn nets as all of the Grade 1 children who used this program suffered this problem. Their explanations were varied. Some children thought the net broke when the boat went too fast while others contended the rocks broke the net. Fish biting through the net was a popular hypothesis, and the ever-popular **'sharky'** often was named as a villain.

Continuing the conversation Emily observed, "Cods are easy to catch; you need to trawl."

The researcher replied, "Did someone tell you that?"

"No", she answered, sounding somewhat indignant. "I just know."

Changing the topic Emily continued, "Sometimes you don't get lobsters at all. You just have to be lucky where you catch your fish. I know where to get fish. I know where to gets [sic] lots and lots of

fish. It's just the trouble with home repairs. It just at the beginning." Emily was not an idle boaster. She did have hypotheses as to where to find both fish and crustaceans. Some of these predictions were accurate to a remarkable degree.

Emily proceeded with her fishing, and accidentally cut her line. Her response, "Oh, Rats!" revealed disappointment, but it appeared short-lived. When asked what had happened, Emily read from the message line on the screen for the first time. "You cut your line...," she started, but her reading was cut short because the screen was replaced automatically with the results screen. "Sometimes, you don't get a trawl at all," she proceeded to explain. Emily was correct in that a student may be left only with drag nets if all the trawl nets have been ruined in the process of fishing. Then, almost as though she was unaware of anyone else's presence, she started "talking" to the net. "Come on, trawl! Catch three fish for me," she implored. When it performed to her satisfaction, she said, "All right!" in a praising tone.

Having caught all the fish, she announced, "I'm going to fish in a different spot next time. You have to go to <Map> if you want to find a new place to fish, and I know where to catch the redfish [she pointed to the symbol for redfish on the legend]... in the black corner, in the black spot is where you catch all the...(pause), well not all the...., but most of the redfish." Another student, Matt, referred to the same spot on the map by saying, "The best fishing spots is [sic] down in these black parts. It's the deepest place. Notice how dark it is?" Gregory also was impressed with the potential of deep water. "You can catch lots of fish in deep water," he said.

As Emily talked, the program accessed the map. The interviewer asked if she had previous experience fishing for redfish in this area. "Me and Gregory know how to do it," she answered. "You go into here. You press <ACTION>, and then you get some redfish when you go to search, cause we know that." The tone in which the last clause was uttered spoke volumes about her confidence and the extent to which Emily seemed to feel ownership over the learning situation.

Emily also knew where to find lobsters. Pointing to three areas of shallow water she explained, "And usually, you get lobsters there, there, and there. And here." Pointing to slightly deeper water, she

continued, "You get high ground in the light blue. And you get darker ground..." She started to add to her explanation, but the fishing screen appeared, and Emily became preoccupied with catching fish. "Do you know why there's not two there?" she said. "Because you can't fish without any fish." Emily laughed as she explained the absence of the commands, <Trawl> and <Drag> from the command line. Beneath her tone, full of amusement, lay a sophisticated observation on the design of the program, in particular, the sequencing of command choices.

Earlier, Emily made an interesting reference to the <Search> function of the boat. The researcher used this prior reference as an opportunity to ask her about the purpose of the <Search> command: "What is the boat doing right now?"

"Well, it's calling the fish," she answered. The up and down sweeping motion of the sonar could lead a child to that conclusion. She added, "And if there's no fish, then you know you've gone in a blank spot. Usually the fish come up right there. I can map it or just leave the fish alone and go to <Menu> or I can go to <Help>. See, there's a "help" right there." She proceeded to spell the word out. It was clear, by this time, that she had come upon one of the "blank" spots. "We want map so we can catch the best fish," she said after she accessed the map. These comments are fascinating because she demonstrated knowledge of the program as well as flexibility in strategies for using the program. Moreover, as she spoke, Emily was trying out a variety of hypotheses about fishing and the nature of the program's operation.

Realizing that she would have to choose another spot on the map to fish, Emily demonstrated a need to explain the failure of her theory about the abundance of fish in the black corner. "Well, usually you catch the fish in the black spots or the blue spots," she said, updating her floating hypothesis to accommodate new data. Emily continued to enlighten the researcher by pointing to the symbols for redfish and the shark in the legend and saying, "It's in either black or blue that you have this or this. When the shark is turned around, you can catch sharks. But I don't want to catch a shark. Usually, the shark hides right there in the corner. I've never tried bringing him out."

The map screen appeared, giving Emily the opportunity to choose another location for fishing. She seemed reluctant to stray too far from the dark areas and followed a diagonal channel of lighter blue water. Then, suddenly, she crossed into shallow water. She explained, "That's where you can get the most fish, I think." Her theory had changed to suit her most recent experience. "I might get lots of sharks. Oh yes, I am going to get a shark; it's turned around," she predicted, pointing to the left-to-right orientation of the shark on the legend. Emily accessed the command <Search> and exclaimed, "Soft ground!" Her comment was made with obvious delight as it revealed the structure of the sea bed. "Are you happy about that?" the researcher inquired. "See, it says soft right there," she said, pointing to the appropriate word on the legend. "And I might get a shark hiding. Sharks come around easily," she added in a tone of feigned fear.

The sonar revealed lobsters, which Emily confirmed aloud by saying, "I'll turn around, and now I'm all ready to catch lobsters. No way my net is going to break here. See? You just pick up the soft ground." She chose the appropriate net, her "dagger" [sic] as it was called. As with other floating hypotheses, Emily modified her earlier notion that nets were broken by leaving them in the water too long. After an impressive haul, the net was brought up to the boat.

When the screen depicting results reappeared, Emily spent time looking at it before accessing the <Return> command. Continuing her tour she said, "There's lots of soft ground if you go into the big spaces. I think I'm going to try a space I've never tried before. There might be a shark there. You can never tell if you get hard ground, rocky ground or soft ground." The comment about the nature of the sea bed was puzzling as earlier she demonstrated knowledge of the legend. Following a hunch, the researcher asked, "From the map you can't tell?"

"Well, you can't tell from the map, but when you get this screen you can tell, when you go to <Search>. You just have to be lucky. Jessica wanted to get some of the soft ground, and I told her she just had to be lucky and she got what she wanted, soft ground," Emily replied.

Before the researcher could pursue Emily's comment, she offered an opinion on the program by saying, "OFFSHORE FISHING is really, really neat." Asked what was neat about the program, Emily answered, "You can get lots of fish; it tells you how much fish you get, and that man right there, that's your boat." Continuing by pointing to the fish gauge, she said, "You can save your picture, and you can get lots and lots of fish and you end up winning." Her final comment here is ironic because many children had little objective success, spending as much as 15 minutes before catching any fish. Perhaps Emily's comment offers an insight into a child's view of winning.

This final brief conversation between Emily and the researcher carrying out the interview showed the full range of the type of hypotheses of which she was capable - the objectively incorrect, the fuzzy, and the perfectly rational. Emily proceeded to access a spot on the map so deep that the bottom of the sea was not visible. The discussion proceeded as follows:

Emily: Let's see what I've got. Well, I don't have any ground. That's for sure.

Researcher: (Pointing to the depth scale.) What do you suppose this might mean?

Emily: Points.

Researcher: Points? Ok. Would they have any special meaning?

Emily: Well, I've 300 here, and I've got bigger numbers here, except 75. It gives me that, how much fish you've caught and this. [Emily pointed to the fish hold gauge.] These fish go right into here and turn into turquoise.

Researcher: Hhmm.

Emily: All right! Look how much fish I've caught, and when you fill it right up to there, well, this is yours too. [Emily pointed to the fuel gauge.] That's how much fish have been, ah, that has been put together.

Researcher: Oh.

Emily: You always have to turn yourself around or you'll never get any fish. You have to hurry before [the fish] disappear.

Researcher: Do they do that sometimes?

Emily: Yeah, and sometimes they escape theirselves [sic]. Ah, I just lost one of my fish. Waaa! [Emily complained in a baby voice.]

Researcher: What happened?

Emily: I don't know why.... [Emily's voice trailed off.] But I still have one fish left. That's Ok. Now don't lose this one. Because every time you cut the line, you lose a fish. There. Sometimes even the shark can cut your line.

The interview was over, but while exiting the program, Emily compared this simulation with PUTTING YOURSELF TOGETHER and DRAW. She mentioned the long periods of waiting necessary in OFFSHORE FISHING adding, "It's the hardest one of all."

The researcher rejoined, "If it's the hardest one, why do you think you like it?

Emily replied truthfully, "Well, because you can catch fish."

Yes, But What Are the Children Telling Us?

Although the preceding case description illustrates the potential learning opportunities that occurred as a result of children using the OFFSHORE FISHING program, they may not have been aware of the significance of what they were doing. A comment from Emily showed that, to her, the most salient aspect of the program was what she could do, not what she could learn. In general, when the students were asked to describe a program, and what they liked about it, most children referred not to the qualities of the program but to what they could do (see Simonson (1987) for another case study of children involved in 'doing' aspects of learning).

Although the children were immersed in 'doing', we observed their floating hypotheses and fuzzy knowledge emerging. We believe the manner in which they were learning is similar to how children in general learn in the real world. In OFFSHORE FISHING, they began by generalizing from a small base of data, for example, the location of the best fishing spots or the best season for trawling. Using this information, no matter how incomplete, they acted on it. At this point, the learner was testing a hypothesis, or, more often, several competing hypotheses. And these hypotheses were not resolved in a

quick, concrete manner. Instead, the child continued to gather data, rework the hypothesis or hypotheses in relation to their experiences, and test them in the program. They did all this without having been told that hypothesizing is a valuable learning activity.

Fuzzy or partial knowledge contributed to the reason for floating hypotheses. For example, some of the children in this study possessed a fuzzy knowledge of legends. Information contained in the legend could be brought to bear in creating hypotheses as to the best locations for fishing, why nets broke, and the types of fish to be caught, but the value of legend knowledge in forming and testing hypotheses was tempered by its fuzziness. For example, rocky seabeds tended to be more dangerous than soft seabeds in terms of net breakage, and the child who gained this knowledge from the legend might use it by fishing carefully and assuring that the dragger did not touch the sea bottom. But such knowledge contributes only partially to the hypothesis because children must break nets on rocky seabeds in order to form the hypothesis in the first place. At this early stage of learning, children tended to float multiple hypotheses because of the myriad of possibilities that could account for net breakage. Knowledge contained in the legend or the child's schema for fishing, fuzzy or otherwise, could facilitate the evolvement of these hypotheses.

Lawler (1985), in an intensive case study of his daughter Miriam and son Robby, described many vignettes of his children floating hypotheses and acting on fuzzy knowledge that are similar to those presented in this report. Lawler's work was carried out primarily in the context of his children working with the LOGO language, although other learning situations were described as well, but the salient similarity is how, in both studies, children used prior knowledge in a particular learning setting to solve problems. And in solving these problems, the children did not proceed from a rigid, preordained paradigm; instead, they formed hypotheses about the situation or problem, and often they worked on more than one competing hypothesis at the same time. The nature of these floating hypotheses was affected directly by the child's schemata, in our case fishing in general, the nature of the computer program, how to use a legend, the nature of sonar, to mention just a few sources of knowledge.

What are the implications of our observations on floating hypotheses and fuzzy knowledge for teachers using computers in the schools? First, we believe there is a place for incidental learning and/or discovery learning, and teachers who allow children free time on computers are facilitating such learning. However, this is not to say teachers should not mediate or extend the discovery process. Conferencing with children, much in the manner described by writing process scholars such as Calkins (1986), seems appropriate in free-time settings as the techniques of conferencing emanate directly from the child's interests.

Consider the following hypothetical conversation where a child has called up OFFSHORE FISHING during free-time at the computer .

Teacher: What are you doing today Janine?

Janine: I'm going to fish.

Teacher: I see you're fishing over here today. Where did you fish last time?

Janine: Oh, I fished for redfish over here, but I didn't catch any.

Teacher: Why do you think you will catch redfish here?

Janine: Sylvia told me there's lots of redfish here. See? There's redfish here (Pointing to the legend).

Teacher: What other kind of fish can you catch?

Janine: I can read some of them. Cod.... I don't know that one.

Teacher: Would you like me to help you?

Janine: Okay. (The teacher would proceed to read the names of the other fish in the legend. Because the reading is in context, and important to the reader, there is a propensity for retention.)

The teacher does not want to turn the session into a 15-minute formal lesson, so a graceful exit is appropriate, leaving the child with new knowledge that can be applied to creating or modifying hypotheses about the program. Over a period of time, without impinging on the joy of fishing, a teacher could foster a variety of skills such as uses of a legend, indicators such as the fish hold, vocabulary related to the program, and general knowledge about the sea.

The second major value of allowing children to work through forbidden fruit lies in the dual notions of a continuum of learning and the teachable moment. In a fourth grade textbook, children may be introduced to the idea and function of legends. Unfortunately, not all children will be prepared to grasp this notion when the text and curriculum decrees they are ready. Further, some children will be unable to see the purpose of legends as they may be presented in a manner unrelated to their world and current interests.

When children use legends as a natural aspect of an activity, as with a program like OFFSHORE FISHING, they develop knowledge of a legend's purpose, format, and use over a period of time. At first, the knowledge may be fuzzy, but by the fourth grade, a relatively sophisticated understanding may have developed. This contention does not imply the teacher should neglect formal instruction on legends; it means that a teacher can build formal instruction on a foundation of experiences. The legend schema children bring to such lessons will permit extensions and variations. The teacher can demonstrate extended uses and have the children apply higher level thinking skills in using legends.

The notion of the teachable moment is familiar to educators, but it carries a Greta Garbo quality - seductive but elusive. The teachable moment is an educator's nirvana, a situation where the student is cognitively ready to learn something, wants to learn something, and the teacher just happens to be on the scene to teach that something. We observed the opportunity for numerous teachable moments as children used technology in Hampton School, and indeed, we noted Sharon and other teachers taking advantage of some of them. We believe free-time use of computers offers opportunities for the teachable moment, but teachers must recognize these possibilities in order to take advantage of them.

One child in particular exemplified how educators might take advantage of the teachable moment. His interaction with the researchers revealed three main prerequisites: intense and sustained interest, readiness, and the availability of someone to help mediate. Dallas experienced great difficulty in most academic tasks and often abandoned assigned activities. Before the SCL Project began, Sharon had a VIC 20 computer in her room. This machine was used for simple drill and practice exercises as well as for games. Dallas was quite fond of the VIC 20 and he was adept at playing the games available on it. Once,

when a substitute teacher would not let him play, he walked out of the classroom announcing he was going home. One of the researchers followed him out in the hall in an effort to dissuade him from carrying out his threat. After a long talk about the need for him to complete his assignments before using the computer, he looked up at the researcher and defended his action by lamenting, "But it's the only thing I'm good at."

The types of skills and attitudes that his teacher hoped Dallas might apply to normal academic tasks sometimes were seen in his use of software. Perseverance, a valued attribute in school settings, is often difficult for children frustrated by lack of success in academic tasks. Yet when working on the computer, Dallas tended to be focused and patient. On one occasion, one of the researchers observed that he worked 15 minutes attempting to catch lobsters in the OFFSHORE FISHING program before his first success. We believe the computer may offer a unique vehicle for engaging some children's interest, and this interest may be used as the link to more traditional academic learning. For example, the interest shown by Dallas in OFFSHORE FISHING may offer an opportunity for the teacher to bring in books on the topic or engage him in writing about some his fishing experiences. Interestingly enough, one of the best stories Dallas wrote during the year was about a fishing trip with his father.

In trying to understand Dallas' approach to learning, we observed an intense curiosity, of which the following example is typical.

Dallas: How come crabs have hard things? When crabs get those things on your skin, does it hurt? [Like Emily, he initially used the word crab when he meant lobster.]

Researcher: When crabs get what things on your skin?

Pointing to the pincers on the lobster, Dallas pretended to pinch himself.

Researcher: Oh, the claws? Do <u>you</u> think it would hurt?

[Dallas nodded his head emphatically, but he wanted to know how much it would hurt.]

Researcher: I don't know.

Dallas: [in a confiding tone] I got bit by one before. Do you know the ones in Africa? I got a pet one of them at home that really hurt badly.

The interest Dallas demonstrated, as well as his perseverance in working through the program, presented the researcher with the opportunity to foster learning. The teaching was contextual, and the print was presented in a holistic manner, a technique consistent with current thinking in literacy education (Goodman, 1986). In the next vignette, Dallas had located the lobster symbol on the legend, and the researcher told him how to pronounce the word.

"Have you ever had lobster?" the researcher asked.

"Lobster," he repeated, his finger still on the word. "Lobster dinner?" he clarified.

"Yes," the researcher accepted.

"Yea, it's good, don't you think it is?"

"Uhuh!"

"Did you go to it?" he asked. This question brought to mind the recent opening of the Red Lobster in Kingston and the current deluge of Red Lobster television advertisements.

"I've had lobster. I've had a lobster dinner," Dallas continued.

"Have you gone to a particular place?" the researcher responded.

"I buy it," he proclaimed.

Dallas then chose a trawl net and promptly cut his line in forgetting to turn the boat. This time, he waited while the researcher read the subsequent message for him. On returning to the fishing screen he noticed, of his own accord, that the message area contained two sentences.

"What does that say?" he asked, for the first time demonstrating that he was aware that the words had a relevant meaning and might be valuable in developing a strategy for catching fish.

The interest Dallas showed toward print in this situation was similar to his interest toward print in general. When print seemed to serve an interest or purpose, he solicited help or would demonstrate great tolerance in completing the activity. For instance, on one occasion he wanted to write a story about a time he went fishing with his father. Not only did Dallas tell one of the researchers the tale in great detail, he painstakingly recopied the story after it had been written down for him. Of course, authors such as Smith

(1978) would argue that Dallas is simply one more example of the need for relevance in literacy education. Our point is that, for some children, the computer may provide another type of opportunity for relevance in the classroom.

Continuing, the researcher proceeded to use Dallas' interest to teach another concept. "See how many I got...just one," Dallas said. He was disappointed because this amount of fish was not enough to show up on the graph representing the catch in the fish hold. The researcher realized that Dallas might be interested in looking more closely at the results screen. This screen, to which students are automatically routed after bringing the net back to the ship, displays the amount of fish caught in numbers. Unlike the graph, even a very small catch would show up as a result on this screen. Because Dallas was keen to see his catch displayed, a teaching opportunity presented itself.

The researcher drew Dallas' attention to the table containing a breakdown of the catch. After some initial confusion, he could see that 0.1 of a ton of fish were in the hold. Dallas was pleased at his discovery that the catch was recorded on the screen. We also speculate that he learned that the table of numbers had an advantage over the graph.

Dallas talked while he fished: "I'm touching high ground again. I caught a couple! I touched high ground. I'm going to catch all of them. I know it, I know it. Yahoo! I got it. I got all of them, I know. Do you think I caught all of them?" He didn't look at the screen containing the results of fish haul at this point, although by the end of the half hour he did so spontaneously. He noticed that the fish hold still appeared empty which disappointed him, however, using his new knowledge about the greater sensitivity of the table of numbers he checked this screen to determine his results. We are not contending that Dallas mastered such concepts as decimals or tons, however, he was able to understand that one form of display allowed him to determine the catch more clearly. Further, he could comprehend, in a rudimentary way, that his catch was increasing.

Several weeks later, Dallas was using OFFSHORE FISHING and called out to the researcher busy with another activity. Pointing to numbers on the screen indicating 0.1 of a ton, he proclaimed happily if

inaccurately, "Look, I've got one ton of lobster!" Again, we believe teachers could build upon such interest and knowledge, using scaffolding techniques. The next step might be learning to read 0.1 of a ton, adding the numbers on the screen, or whatever was important to Dallas at that time.

OFFSHORE FISHING even provided the researcher and Dallas an opportunity to look at the affective side of fishing as can be seen in the following exchange:

"How come I never caught all ... did I?" Dallas asked.

"I don't think you caught all of them, No," the researcher confirmed his suspicion. "Is fishing hard?" the researcher asked.

Dallas' nod combined with the rueful look on his face would probably comfort the hearts of many an Atlantic fisher; by way of his vicarious experience in OFFSHORE FISHING, he had come to understand one of the fundamental truths of fishing.

But empathy was not enough. Dallas wanted a more direct answer, and as seen by this final exchange, he doggedly pursued the researcher:

"How come I never caught all of them when I did [when I fished]?"

"Do you think a fisherman catches all of them when he puts out his net?" the researcher asked, lapsing into a gender stereotype.

"No," Dallas replied.

The researcher took this opportunity to press the point home. "So do you think that is maybe why you didn't catch all them?" she said.

He nodded his head absently, but he seemed to have more important things on his mind at the moment - lobsters!

Lessons from the Interviews

As described previously in the Research Methodology section of this report, each child was interviewed individually at the end of the year. These interviews were designed to elicit information concerning children's software preferences, knowledge of the computer, and ability to use various programs.